

Towards Predicting the Impact of Climate Change on Tourism: An Hourly Tourism Climate Index

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Abstract

This study presents a tourism climate index based on hourly weather data. We use the index to assess changes in weather conditions conducive to outdoor activities at two destinations in Alaska: King Salmon (near Katmai National Park and Preserve) and Anchorage. The results indicate that climate warming has had both positive and negative effects on opportunities for tourism. The overall weather conditions for sightseeing in King Salmon have improved significantly, along with a lengthening of the season. Conversely, weather conditions for skiing in Anchorage have deteriorated since the 1940s, primarily because the end date of weather suitable for skiing during the late winter now occurs earlier. The results indicate that impacts of climate change will vary widely among locations and among different types of tourist activities.

Introduction

Tourism is an important segment of Alaska's economy, with millions of visitors a year. The direct and indirect effects of travel and tourist expenditures (not including multiplier effects) in Alaska have been between \$1.5 and \$2 billion in recent years. Tourism in Alaska exhibits clear seasonal patterns with 80% of visitors arriving between May and September (*Alaska Economic Performance Report 2005*), the majority of whom

engage in outdoor activities. National parks are among the most popular destinations, and there is little doubt that the quality of a visitor's experience is affected by the weather. This work addresses changes in climate and associated changes in weather that have implications for national parks and, more generally, outdoor tourism in Alaska. It draws upon the notion that climate can be viewed as a tourism resource.

Climate can affect tourism in several ways. The direct effect, which is addressed in this work, arises from the effect of weather on the outdoor experience of a tourist. The indirect effect, which can be even more important in the long-term, pertains to effects of climate on wildlife, glaciers and ecology of a region. These characteristics affect the attractiveness of a tourist destination. For example, if climate were to drive a significant exodus of bears from Katmai National Park and Preserve, bear-viewing tourism would obviously be impacted. The present work does not address this type of longer-term climatic impact.

An abundance of evidence suggests that Alaska is warming, most noticeably in winter and spring (*Figure 2*). This has led to an earlier transition from winter to spring and a later transition from fall to winter. The impact of these seasonal changes is already being felt by various sectors of industry and by indigenous communities (*ACIA 2005*). For example, Gregory et al. (2006) report that climate changes in Northwest Alaska are impacting the timing of resource availability (fishing, hunting) and access to resources such



Figure 1. Bear viewing in Katmai National Park & Preserve.

as ice, rivers, and the ocean.

Despite the overwhelming evidence that significant seasonal changes are occurring in Alaska, and despite the recognition that these climate changes are bound to impact tourism, there has been little empirical research addressing the climate change/tourism domain in Alaska. The present study extends the research on impacts of climate, by using Alaska as a case study for the use of an hourly tourism climate index to assess the existence of favorable weather conditions for specific tourism activities (i.e., summer outdoor activities and winter skiing). More generally, the purpose of this study is to devise and test a quantitative tool for

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measuring climate as a tourism resource. The methodology presented here utilizes multivariate information at high temporal resolution, thereby bridging the weather that tourists experience in practice and the climate information that is generally represented by averages.

Methods

The methodology utilizes a three-level climate index for tourism (CIT) where a value of 2 denotes favorable conditions for an outdoor activity, 1 denotes marginal conditions, and 0 denotes unsuitable conditions (Yu and Schwartz 2007). The CIT combines several critical weather elements, including temperature, wind speed, visibility and falling precipitation. The index builds upon previous attempts to quantify tourism-related climate conditions, allowing for more detailed applications and in-depth statistical analysis.

A unique feature of this index is the use of hourly weather observations. Hourly data contain more valuable information than statistical data (such as averages, maxima and minima) when measuring the suitability of weather conditions for outdoor tourism activity. Weather elements such as rain, thunderstorms and visibility can vary within a day and are often tied to the diurnal cycle, as are many tourist activities. The intermittency of certain types of weather can be lost in daily and especially monthly averages. For example, a day with total precipitation of 1 inch could be the result of a one-hour intense downpour, or 12 hours of lighter rain. It could occur during mid-day or at midnight.

An hourly index can be tailored for a specific tourism activity that requires particular weather conditions during a particular time of day. It can provide micro-level information on the number and seasonal patterns of days or hours suitable for a specific tourism activity, in an area with specific natural resources (e.g., beach and mountain). It can capture, through “frequency” statistics such as those presented here, the probabilities that particular hours (or subsets of hours) will be suitable for a particular outdoor activity—a level of

detail that cannot be obtained from monthly or even daily data.

The four variables on which the hourly index is based are (i) perceived temperature (heat index in summer, wind chill in winter), (ii) wind speed, (iii) visibility and (iv) present weather (a synoptic element, indicating type and intensity of any precipitation, thunder, lightning, smoke, blowing dust, etc.). Each variable is assigned a value of 2 for favorable, 1 for marginal and 0 for unsuitable conditions. The four subindex values determine the CIT, which is 2 if all four subindices are 2, 0 if any of the four subindices are 0, and 1 otherwise. This assignment of CIT values illustrates the overriding nature of the four weather elements: if any one of the four is unsuitable, the aggregate CIT index is in the unsuitable category.

Hourly weather observations from two destinations in Alaska, King Salmon (1943-2005) and Anchorage (1942-2005), were used in this study. Summer sightseeing and fishing are the main tourism attractions in King Salmon, which is located a short distance from Katmai National Park and Preserve (Katmai), a renowned area for viewing bears and other wildlife. Here we use King Salmon as a proxy for Katmai. Anchorage is the most popular area for skiing in Alaska. The city’s wealth of cross-country ski trails gives it a higher concentration of urban skiers than any other city in the United States, and the close proximity of several major downhill ski areas attracts local as well as out-of-state skiers.

King Salmon’s summer season length was quantified using hourly values of the CIT that were based on thresholds specified to capture suitability of weather conditions for sightseeing (favorable conditions require perceived temperature between 40° and 85°F, wind speed less than 13 mph, visibility at least 4 miles, and absence of precipitation/smoke/dust). Anchorage’s winter season length was quantified using CIT values based on thresholds specified to capture suitability for skiing (favorable conditions require perceived temperature between -10° and 32°F, and the other variables in the same range as for sightseeing conditions). In addition, for comparative purposes we have performed the

Total Change in Mean Seasonal and Annual Temperature (°F), 1949 - 2007

Region	Location	Winter	Spring	Summer	Autumn	Annual
Arctic	Barrow	6.3	4.3	2.9	3.0	4.2
	Bettles	8.7	4.7	2.1	1.5	4.2
	Big Delta	9.6	3.5	1.5	0.2	3.7
	Fairbanks	8.0	3.8	2.4	0	3.6
	McGrath	7.5	4.8	2.9	1.1	4.1
West Coast	Kotzebue	7.0	1.8	2.7	1.8	3.3
	Nome	5.0	3.9	2.7	1.0	3.2
	Bethel	7.0	5.3	2.5	0.7	3.9
	King Salmon	8.8	5.0	2.0	1.1	4.2
	Cold Bay	1.9	2.1	2.0	1.1	1.8
Southcentral	St Paul	1.3	2.8	3.1	1.6	2.2
	Anchorage	7.1	3.6	1.9	1.6	3.4
	Talkeetna	9.2	5.4	3.4	2.6	5.2
	Gulkana	8.4	2.2	1.1	0.2	3.0
	Homer	6.7	4.1	3.6	2.0	4.2
Southeast	Kodiak	1.2	2.5	1.5	-0.1	1.3
	Yakutat	5.1	3.1	2.0	0.3	2.7
	Juneau	6.8	3.2	2.4	1.4	3.5
	Annette	4.1	2.7	1.9	0.3	2.3
Average		6.3	3.6	2.3	1.1	3.4

Figure 2. Annual and seasonal temperature changes (°F) in Alaska, 1949-2006. [From Alaska Climate Research Center, <http://climate.gi.alaska.edu/ClimTrends/Change/TempChange.html>].

same calculations for Orlando, Florida, which is heavily dependent on tourism.

Results

At King Salmon, the frequency of favorable CIT (Figure 3) exhibits a pronounced seasonal cycle, ranging from zero in the winter to approximately 45% in summer. The corresponding curves for the subindices show that perceived temperature is the main controller of the seasonal cycle. However, the other factors are also important, as they reduce the frequency from about 95% (perceived temperature’s summer peak) to about 45% (aggregate CIT’s summer peak). Of the other three elements, wind speed has the greatest effect, followed by present weather and visibility.

The average seasonal cycle shown in Figure 3 is subject to substantial interannual variability and also to changes over time. By comparing two years (1956 and 2005), we see the seasonal cycle of King Salmon change (Figure 4). If one

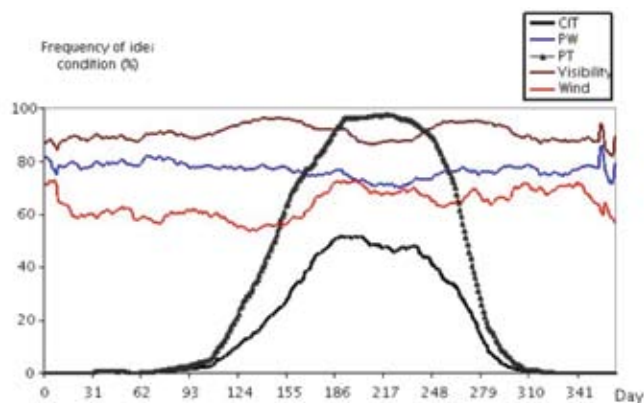


Figure 3. The climate index for tourism (CIT) and the four subindices, present weather (PW), perceived temperature (PT), wind speed and visibility, showing the frequency of favorable conditions for sightseeing at King Salmon. Note the seasonal cycle.

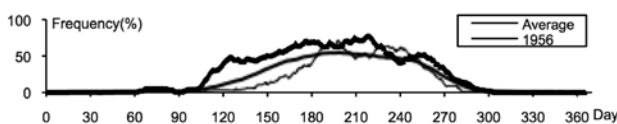


Figure 4. The frequency of favorable conditions for sightseeing (CIT) at King Salmon for two individual years, 1956 and 2005, together with the mean seasonal cycle for 1943-2005.

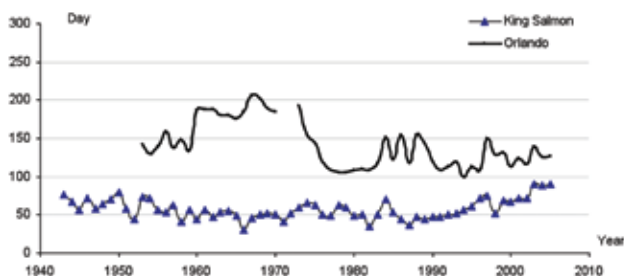


Figure 5. Number of days per year with at least five consecutive hours of favorable sightseeing conditions between 8 am and 7 pm at King Salmon, AK (blue) and Orlando (black).

assumes a threshold frequency of 30-40% for the start and end of the sightseeing season, it is apparent that the start date can vary by nearly two months. While 1956 and 2005 were chosen because they are extreme examples, year-to-year differences in the start and end dates are typically one to several weeks. The data show that the end dates of the 1956 and 2005 seasons were not substantially different. This trend towards an earlier start date but little change in end date is actually representative of the broader time series for King Salmon, as discussed further below.

In addition to the year-to-year variations, there are trends over time in the length and quality of the sightseeing season. As an illustration of the CIT's ability to capture such variations, Figure 4 shows the number of days per year in which sightseeing conditions were favorable for at least five consecutive hours between 8 am and 7 pm. Also shown for comparison is the corresponding curve for Orlando, Florida. The number of days favorable for sightseeing at King Salmon has increased substantially since the 1980s. For the last several years, the season length was about 30 days longer than during the 1960s and 1970s. By contrast, the corresponding series for Orlando shows a post-1970 decrease in the number of favorable days. In both cases, temperature is the main driver of the changes. The springtime warming of Alaska, noted earlier (Figure 2), has resulted in more favorable conditions in the early part of the season (May-June), effectively lengthening the season. At Orlando, summer warming has resulted in many days that exceed the heat index threshold during the summer.

We also applied the index to seasonal patterns of weather for skiing at Anchorage. When each year is assigned to a particular pattern by the statistical clustering algorithm, a trend towards less favorable skiing conditions emerged. Specifically, seasons with earlier end dates have increased significantly in frequency in the past several decades, while patterns corresponding to longer seasons have decreased in frequency. The earlier end dates are consistent with the winter-spring warming noted earlier.

Discussion and conclusions

The methodology used here integrates hourly and daily frequency distributions to allow quantification of seasonal patterns for specific tourism activities. It enables more detailed examination of the shift in seasonal patterns as well as closer scrutiny of the impact of climate change on seasonal patterns of weather variables that impact tourists. The results of this study indicate that recent climatic warming has had both positive and negative effects on tourism weather in Alaska. A longer summer season with high-quality weather conditions benefits tourism activities such as sightseeing, whereas a shorter winter season negatively impacts ski tourism. By contrast, subtropical locations such as Orlando are seeing a decline in favorable outdoor conditions during summer, primarily because summer temperatures at such locations are already near the upper limit of the favorable range.

Management implications

The impact of climate change on tourism is expected to be diverse and wide-ranging, and will depend upon location and geography. The method discussed in this paper can be used to assess the impact of climate change on other tourism sectors and other locations. This assessment of the impact of climate change on specific aspects of seasonal patterns could prove useful in tourism planning. For example, tour operators can shift seasonal schedules to take advantage of the shift towards an earlier start of the summer season, and destination marketing could be adjusted to better communicate the changes in favorable conditions to prospective travelers.

Acknowledgments

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Figure 6. Sea kayakers navigate glacial ice.